

4.E: Chemical Reactions and Equations (Exercises)

Exercises (The Chemical Equation)

1. From the statement “nitrogen and hydrogen react to produce ammonia,” identify the reactants and the products.
2. From the statement “sodium metal reacts with water to produce sodium hydroxide and hydrogen,” identify the reactants and the products.
3. From the statement “magnesium hydroxide reacts with nitric acid to produce magnesium nitrate and water,” identify the reactants and the products.
4. From the statement “propane reacts with oxygen to produce carbon dioxide and water,” identify the reactants and the products.
5. Write and balance the chemical equation described by Exercise 1.
6. Write and balance the chemical equation described by Exercise 2.
7. Write and balance the chemical equation described by Exercise 3.
8. Write and balance the chemical equation described by Exercise 4. The formula for propane is C_3H_8 .
9. Balance: $__NaClO_3 \rightarrow __NaCl + __O_2$
10. Balance: $__N_2 + __H_2 \rightarrow __N_2H_4$
11. Balance: $__Al + __O_2 \rightarrow __Al_2O_3$
12. Balance: $__C_2H_4 + __O_2 \rightarrow __CO_2 + __H_2O$
13. How would you write the balanced chemical equation in Exercise 10 if all substances were gases?
14. How would you write the balanced chemical equation in Exercise 12 if all the substances except water were gases and water itself were a liquid?

Answers

1. reactants: nitrogen and hydrogen; product: ammonia
3. reactants: magnesium hydroxide and nitric acid; products: magnesium nitrate and water
5. $N_2 + 3H_2 \rightarrow 2NH_3$
7. $Mg(OH)_2 + 2HNO_3 \rightarrow Mg(NO_3)_2 + 2H_2O$
9. $2NaClO_3 \rightarrow 2NaCl + 3O_2$
11. $4Al + 3O_2 \rightarrow 2Al_2O_3$
13. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

Exercises (Types of Chemical Reactions - Single and Double Displacement Reactions)

1. What are the general characteristics that help you recognize single-replacement reactions?
2. What are the general characteristics that help you recognize double-replacement reactions?
3. Assuming that each single-replacement reaction occurs, predict the products and write each balanced chemical equation.
 - a. $Zn + Fe(NO_3)_2 \rightarrow ?$
 - b. $F_2 + FeI_3 \rightarrow ?$
4. Assuming that each single-replacement reaction occurs, predict the products and write each balanced chemical equation.
 - a. $Li + MgSO_4 \rightarrow ?$
 - b. $NaBr + Cl_2 \rightarrow ?$
5. Assuming that each single-replacement reaction occurs, predict the products and write each balanced chemical equation.

- a. $\text{Sn} + \text{H}_2\text{SO}_4 \rightarrow ?$
b. $\text{Al} + \text{NiBr}_2 \rightarrow ?$
6. Assuming that each single-replacement reaction occurs, predict the products and write each balanced chemical equation.
a. $\text{Mg} + \text{HCl} \rightarrow ?$
b. $\text{HI} + \text{Br}_2 \rightarrow ?$
7. Use the periodic table or the activity series to predict if each single-replacement reaction will occur and, if so, write a balanced chemical equation.
a. $\text{FeCl}_2 + \text{Br}_2 \rightarrow ?$
b. $\text{Fe}(\text{NO}_3)_3 + \text{Al} \rightarrow ?$
8. Use the periodic table or the activity series to predict if each single-replacement reaction will occur and, if so, write a balanced chemical equation.
a. $\text{Zn} + \text{Fe}_3(\text{PO}_4)_2 \rightarrow ?$
b. $\text{Ag} + \text{HNO}_3 \rightarrow ?$
9. Use the periodic table or the activity series to predict if each single-replacement reaction will occur and, if so, write a balanced chemical equation.
a. $\text{NaI} + \text{Cl}_2 \rightarrow ?$
b. $\text{AgCl} + \text{Au} \rightarrow ?$
10. Use the periodic table or the activity series to predict if each single-replacement reaction will occur and, if so, write a balanced chemical equation.
a. $\text{Pt} + \text{H}_3\text{PO}_4 \rightarrow ?$
b. $\text{Li} + \text{H}_2\text{O} \rightarrow ?$ (Hint: treat H_2O as if it were composed of H^+ and OH^- ions.)
11. Assuming that each double-replacement reaction occurs, predict the products and write each balanced chemical equation.
a. $\text{Zn}(\text{NO}_3)_2 + \text{NaOH} \rightarrow ?$
b. $\text{HCl} + \text{Na}_2\text{S} \rightarrow ?$
12. Assuming that each double-replacement reaction occurs, predict the products and write each balanced chemical equation.
a. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{HNO}_3 \rightarrow ?$
b. $\text{Na}_2\text{CO}_3 + \text{Sr}(\text{NO}_2)_2 \rightarrow ?$
13. Assuming that each double-replacement reaction occurs, predict the products and write each balanced chemical equation.
a. $\text{Pb}(\text{NO}_3)_2 + \text{KBr} \rightarrow ?$
b. $\text{K}_2\text{O} + \text{MgCO}_3 \rightarrow ?$
14. Assuming that each double-replacement reaction occurs, predict the products and write each balanced chemical equation.
a. $\text{Sn}(\text{OH})_2 + \text{FeBr}_3 \rightarrow ?$
b. $\text{CsNO}_3 + \text{KCl} \rightarrow ?$
15. Use the solubility rules to predict if each double-replacement reaction will occur and, if so, write a balanced chemical equation.
a. $\text{Pb}(\text{NO}_3)_2 + \text{KBr} \rightarrow ?$
b. $\text{K}_2\text{O} + \text{Na}_2\text{CO}_3 \rightarrow ?$
16. Use the solubility rules to predict if each double-replacement reaction will occur and, if so, write a balanced chemical equation.

- a. $\text{Na}_2\text{CO}_3 + \text{Sr}(\text{NO}_2)_2 \rightarrow ?$
- b. $(\text{NH}_4)_2\text{SO}_4 + \text{Ba}(\text{NO}_3)_2 \rightarrow ?$

17. Use the solubility rules to predict if each double-replacement reaction will occur and, if so, write a balanced chemical equation.

- a. $\text{K}_3\text{PO}_4 + \text{SrCl}_2 \rightarrow ?$
- b. $\text{NaOH} + \text{MgCl}_2 \rightarrow ?$

18. Use the solubility rules to predict if each double-replacement reaction will occur and, if so, write a balanced chemical equation.

- a. $\text{KC}_2\text{H}_3\text{O}_2 + \text{Li}_2\text{CO}_3 \rightarrow ?$
- b. $\text{KOH} + \text{AgNO}_3 \rightarrow ?$

Answers

1. One element replaces another element in a compound.

3.

- a. $\text{Zn} + \text{Fe}(\text{NO}_3)_2 \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{Fe}$
- b. $3\text{F}_2 + 2\text{FeI}_3 \rightarrow 3\text{I}_2 + 2\text{FeF}_3$

5.

- a. $\text{Sn} + \text{H}_2\text{SO}_4 \rightarrow \text{SnSO}_4 + \text{H}_2$
- b. $2\text{Al} + 3\text{NiBr}_2 \rightarrow 2\text{AlBr}_3 + 3\text{Ni}$

7.

- a. No reaction occurs.
- b. $\text{Fe}(\text{NO}_3)_3 + \text{Al} \rightarrow \text{Al}(\text{NO}_3)_3 + \text{Fe}$

9.

- a. $2\text{NaI} + \text{Cl}_2 \rightarrow 2\text{NaCl} + \text{I}_2$
- b. No reaction occurs.

11.

1. $\text{Zn}(\text{NO}_3)_2 + 2\text{NaOH} \rightarrow \text{Zn}(\text{OH})_2 + 2\text{NaNO}_3$
2. $2\text{HCl} + \text{Na}_2\text{S} \rightarrow 2\text{NaCl} + \text{H}_2\text{S}$

13.

- a. $\text{Pb}(\text{NO}_3)_2 + 2\text{KBr} \rightarrow \text{PbBr}_2 + 2\text{KNO}_3$
- b. $\text{K}_2\text{O} + \text{MgCO}_3 \rightarrow \text{K}_2\text{CO}_3 + \text{MgO}$

15.

- a. $\text{Pb}(\text{NO}_3)_2 + 2\text{KBr} \rightarrow \text{PbBr}_2(\text{s}) + 2\text{KNO}_3$
- b. No reaction occurs.

17.

- a. $2\text{K}_3\text{PO}_4 + 3\text{SrCl}_2 \rightarrow \text{Sr}_3(\text{PO}_4)_2(\text{s}) + 6\text{KCl}$
- b. $2\text{NaOH} + \text{MgCl}_2 \rightarrow 2\text{NaCl} + \text{Mg}(\text{OH})_2(\text{s})$

Exercises (Ionic Equations - A Closer Look)

- Write a chemical equation that represents $\text{NaBr}(\text{s})$ dissociating in water.
- Write a chemical equation that represents $\text{SrCl}_2(\text{s})$ dissociating in water.
- Write a chemical equation that represents $(\text{NH}_4)_3\text{PO}_4(\text{s})$ dissociating in water.
- Write a chemical equation that represents $\text{Fe}(\text{C}_2\text{H}_3\text{O}_2)_3(\text{s})$ dissociating in water.
- Write the complete ionic equation for the reaction of $\text{FeCl}_2(\text{aq})$ and $\text{AgNO}_3(\text{aq})$. You may have to consult the solubility rules.

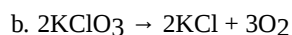
6. Write the complete ionic equation for the reaction of $\text{BaCl}_2(\text{aq})$ and $\text{Na}_2\text{SO}_4(\text{aq})$. You may have to consult the solubility rules.
7. Write the complete ionic equation for the reaction of $\text{KCl}(\text{aq})$ and $\text{NaC}_2\text{H}_3\text{O}_2(\text{aq})$. You may have to consult the solubility rules.
8. Write the complete ionic equation for the reaction of $\text{Fe}_2(\text{SO}_4)_3(\text{aq})$ and $\text{Sr}(\text{NO}_3)_2(\text{aq})$. You may have to consult the solubility rules.
9. Write the net ionic equation for the reaction of $\text{FeCl}_2(\text{aq})$ and $\text{AgNO}_3(\text{aq})$. You may have to consult the solubility rules.
10. Write the net ionic equation for the reaction of $\text{BaCl}_2(\text{aq})$ and $\text{Na}_2\text{SO}_4(\text{aq})$. You may have to consult the solubility rules.
11. Write the net ionic equation for the reaction of $\text{KCl}(\text{aq})$ and $\text{NaC}_2\text{H}_3\text{O}_2(\text{aq})$. You may have to consult the solubility rules.
12. Write the net ionic equation for the reaction of $\text{Fe}_2(\text{SO}_4)_3(\text{aq})$ and $\text{Sr}(\text{NO}_3)_2(\text{aq})$. You may have to consult the solubility rules.
13. Identify the spectator ions in Exercises 9 and 10.
14. Identify the spectator ions in Exercises 11 and 12.

Answers

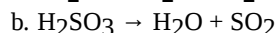
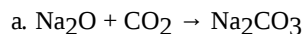
1. $\text{NaBr}(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{Na}^+(\text{aq}) + \text{Br}^-(\text{aq})$
3. $(\text{NH}_4)_3\text{PO}_4(\text{s}) \xrightarrow{\text{H}_2\text{O}} 3\text{NH}_4^+(\text{aq}) + \text{PO}_4^{3-}(\text{aq})$
5. $\text{Fe}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) + 2\text{Ag}^+(\text{aq}) + 2\text{NO}_3^-(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq}) + 2\text{AgCl}(\text{s})$
7. $\text{K}^+(\text{aq}) + \text{Cl}^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{C}_2\text{H}_3\text{O}_2^-(\text{aq}) \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) + \text{K}^+(\text{aq}) + \text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$
9. $2\text{Cl}^-(\text{aq}) + 2\text{Ag}^+(\text{aq}) \rightarrow 2\text{AgCl}(\text{s})$
11. There is no overall reaction.
13. In Exercise 9, $\text{Fe}^{2+}(\text{aq})$ and $\text{NO}_3^-(\text{aq})$ are spectator ions; in Exercise 10, $\text{Na}^+(\text{aq})$ and $\text{Cl}^-(\text{aq})$ are spectator ions.

Exercises (Composition, Decomposition, and Combustion Reactions)

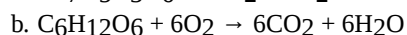
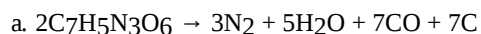
1. Which is a composition reaction and which is not?
 - a. $\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} + \text{NaNO}_3$
 - b. $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$
2. Which is a composition reaction and which is not?
 - a. $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$
 - b. $2\text{HBr} + \text{Cl}_2 \rightarrow 2\text{HCl} + \text{Br}_2$
3. Which is a composition reaction and which is not?
 - a. $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
 - b. $6\text{C} + 3\text{H}_2 \rightarrow \text{C}_6\text{H}_6$
4. Which is a composition reaction and which is not?
 - a. $4\text{Na} + 2\text{C} + 3\text{O}_2 \rightarrow 2\text{Na}_2\text{CO}_3$
 - b. $\text{Na}_2\text{CO}_3 \rightarrow \text{Na}_2\text{O} + \text{CO}_2$
5. Which is a decomposition reaction and which is not?
 - a. $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
 - b. $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
6. Which is a decomposition reaction and which is not?
 - a. $3\text{O}_2 \rightarrow 2\text{O}_3$



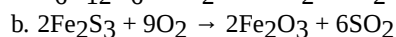
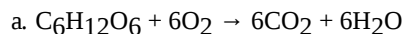
7. Which is a decomposition reaction and which is not?



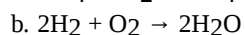
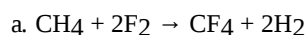
8. Which is a decomposition reaction and which is not?



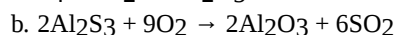
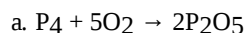
9. Which is a combustion reaction and which is not?



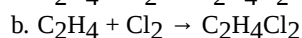
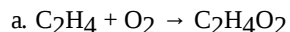
10. Which is a combustion reaction and which is not?



11. Which is a combustion reaction and which is not?



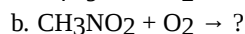
12. Which is a combustion reaction and which is not?



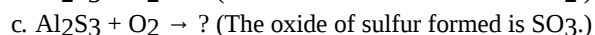
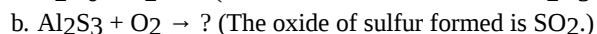
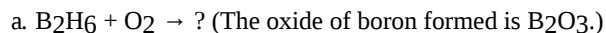
13. Is it possible for a composition reaction to also be a combustion reaction? Give an example to support your case.

14. Is it possible for a decomposition reaction to also be a combustion reaction? Give an example to support your case.

15. Complete and balance each combustion equation.



16. Complete and balance each combustion equation.



Answers

1.

a. not composition

b. composition

3.

a. composition

b. composition

5.

- a. not decomposition
- b. decomposition

7.

- a. not decomposition
- b. decomposition

9.

- a. combustion
- b. combustion

11.

- a. combustion
- b. combustion

13. Yes; $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ (answers will vary)

15.

- a. $\text{C}_4\text{H}_9\text{OH} + 6\text{O}_2 \rightarrow 4\text{CO}_2 + 5\text{H}_2\text{O}$
- b. $4\text{CH}_3\text{NO}_2 + 3\text{O}_2 \rightarrow 4\text{CO}_2 + 6\text{H}_2\text{O} + 2\text{N}_2$

Exercises (Neutralization Reactions)

1. What is the Arrhenius definition of an acid?
2. What is the Arrhenius definition of a base?
3. Predict the products of each acid-base combination listed. Assume that a neutralization reaction occurs.
 - a. HCl and KOH
 - b. H_2SO_4 and KOH
 - c. H_3PO_4 and $\text{Ni}(\text{OH})_2$
4. Predict the products of each acid-base combination listed. Assume that a neutralization reaction occurs.
 - a. HBr and $\text{Fe}(\text{OH})_3$
 - b. HNO_2 and $\text{Al}(\text{OH})_3$
 - c. HClO_3 and $\text{Mg}(\text{OH})_2$
5. Write a balanced chemical equation for each neutralization reaction in Exercise 3.
6. Write a balanced chemical equation for each neutralization reaction in Exercise 4.
7. Write a balanced chemical equation for the neutralization reaction between each given acid and base. Include the proper phase labels.
 - a. $\text{HI}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow ?$
 - b. $\text{H}_2\text{SO}_4(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow ?$
8. Write a balanced chemical equation for the neutralization reaction between each given acid and base. Include the proper phase labels.
 - a. $\text{HNO}_3(\text{aq}) + \text{Fe}(\text{OH})_3(\text{s}) \rightarrow ?$
 - b. $\text{H}_3\text{PO}_4(\text{aq}) + \text{CsOH}(\text{aq}) \rightarrow ?$
9. Write the net ionic equation for each neutralization reaction in Exercise 7.

10. Write the net ionic equation for each neutralization reaction in Exercise 8.
11. Write the complete and net ionic equations for the neutralization reaction between $\text{HClO}_3(\text{aq})$ and $\text{Zn}(\text{OH})_2(\text{s})$. Assume the salt is soluble.
12. Write the complete and net ionic equations for the neutralization reaction between $\text{H}_2\text{C}_2\text{O}_4(\text{s})$ and $\text{Sr}(\text{OH})_2(\text{aq})$. Assume the salt is insoluble.
13. Explain why the net ionic equation for the neutralization reaction between $\text{HCl}(\text{aq})$ and $\text{KOH}(\text{aq})$ is the same as the net ionic equation for the neutralization reaction between $\text{HNO}_3(\text{aq})$ and RbOH .
14. Explain why the net ionic equation for the neutralization reaction between $\text{HCl}(\text{aq})$ and $\text{KOH}(\text{aq})$ is different from the net ionic equation for the neutralization reaction between $\text{HCl}(\text{aq})$ and AgOH .
15. Write the complete and net ionic equations for the neutralization reaction between $\text{HCl}(\text{aq})$ and $\text{KOH}(\text{aq})$ using the hydronium ion in place of H^+ . What difference does it make when using the hydronium ion?
16. Write the complete and net ionic equations for the neutralization reaction between $\text{HClO}_3(\text{aq})$ and $\text{Zn}(\text{OH})_2(\text{s})$ using the hydronium ion in place of H^+ . Assume the salt is soluble. What difference does it make when using the hydronium ion?

Answers

1. An Arrhenius acid increases the amount of H^+ ions in an aqueous solution.
3.
 - a. KCl and H_2O
 - b. K_2SO_4 and H_2O
 - c. $\text{Ni}_3(\text{PO}_4)_2$ and H_2O
5.
 - a. $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$
 - b. $\text{H}_2\text{SO}_4 + 2\text{KOH} \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
 - c. $2\text{H}_3\text{PO}_4 + 3\text{Ni}(\text{OH})_2 \rightarrow \text{Ni}_3(\text{PO}_4)_2 + 6\text{H}_2\text{O}$
7.
 - a. $\text{HI}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{KI}(\text{aq}) + \text{H}_2\text{O}(\ell)$
 - b. $\text{H}_2\text{SO}_4(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{H}_2\text{O}(\ell)$
9.
 - a. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell)$
 - b. $2\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + \text{Ba}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{H}_2\text{O}(\ell)$
11. Complete ionic equation:

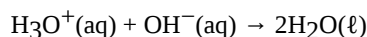
$$2\text{H}^+(\text{aq}) + 2\text{ClO}_3^-(\text{aq}) + \text{Zn}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{ClO}_3^-(\text{aq}) + 2\text{H}_2\text{O}(\ell)$$
 Net ionic equation:

$$2\text{H}^+(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\ell)$$
13. Because the salts are soluble in both cases, the net ionic reaction is just

$$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell).$$
15. Complete ionic equation:

$$\text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq}) + \text{K}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\ell) + \text{K}^+(\text{aq}) + \text{Cl}^-(\text{aq})$$

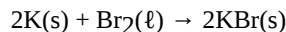
Net ionic equation:



17. The difference is simply the presence of an extra water molecule as a product.

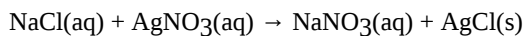
Exercises (Oxidation-Reduction Reactions)

1. Is the reaction



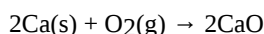
an oxidation-reduction reaction? Explain your answer.

2. Is the reaction



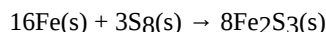
an oxidation-reduction reaction? Explain your answer.

3. In the reaction



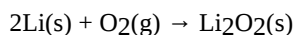
indicate what has lost electrons and what has gained electrons.

4. In the reaction



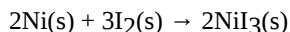
indicate what has lost electrons and what has gained electrons.

5. In the reaction



indicate what has been oxidized and what has been reduced.

6. In the reaction



indicate what has been oxidized and what has been reduced.

7. What are two different definitions of oxidation?

8. What are two different definitions of reduction?

9. Assign oxidation numbers to each atom in each substance.

- a. P_4
- b. SO_2
- c. SO_3^{2-}
- d. $\text{Ca}(\text{NO}_3)_2$

10. Assign oxidation numbers to each atom in each substance.

- a. PF_5
- b. $(\text{NH}_4)_2\text{S}$
- c. Hg
- d. Li_2O_2 (lithium peroxide)

11. Assign oxidation numbers to each atom in each substance.

- a. CO
- b. CO_2
- c. NiCl_2

d. NiCl_3

12. Assign oxidation numbers to each atom in each substance.

- a. NaH (sodium hydride)
- b. NO_2
- c. NO_2^-
- d. AgNO_3

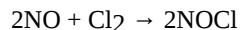
13. Assign oxidation numbers to each atom in each substance.

- a. CH_2O
- b. NH_3
- c. Rb_2SO_4
- d. $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$

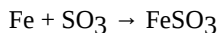
14. Assign oxidation numbers to each atom in each substance.

- a. C_6H_6
- b. $\text{B}(\text{OH})_3$
- c. Li_2S
- d. Au

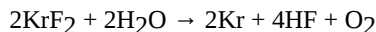
15. Identify what is being oxidized and reduced in this redox equation by assigning oxidation numbers to the atoms.



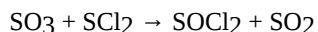
16. Identify what is being oxidized and reduced in this redox equation by assigning oxidation numbers to the atoms.



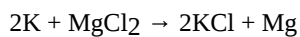
17. Identify what is being oxidized and reduced in this redox equation by assigning oxidation numbers to the atoms.



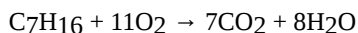
18. Identify what is being oxidized and reduced in this redox equation by assigning oxidation numbers to the atoms.



19. Identify what is being oxidized and reduced in this redox equation by assigning oxidation numbers to the atoms.



20. Identify what is being oxidized and reduced in this redox equation by assigning oxidation numbers to the atoms.



Answers

1. Yes; both K and Br are changing oxidation numbers.

3. Ca has lost electrons, and O has gained electrons.

5. Li has been oxidized, and O has been reduced.

7. loss of electrons; increase in oxidation number

9.

- a. P: 0
- b. S: +4; O: -2
- c. S: +2; O: -2
- d. Ca: 2+; N: +5; O: -2

11.

- a. C: +2; O: -2
- b. C: +4; O: -2
- c. Ni: +2; Cl: -1
- d. Ni: +3; Cl: -1

13.

- a. C: 0; H: +1; O: -2
- b. N: -3; H: +1
- c. Rb: +1; S: +6; O: -2
- d. Zn: +2; C: 0; H: +1; O: -2

15. N is being oxidized, and Cl is being reduced.

17. O is being oxidized, and Kr is being reduced.

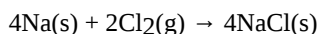
19. K is being oxidized, and Mg is being reduced.

Additional Exercises

1. Chemical equations can also be used to represent physical processes. Write a chemical reaction for the boiling of water, including the proper phase labels.

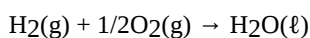
2. Chemical equations can also be used to represent physical processes. Write a chemical reaction for the freezing of water, including the proper phase labels.

3. Explain why



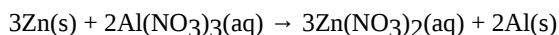
should not be considered a proper chemical equation.

4. Explain why



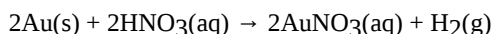
should not be considered a proper chemical equation.

5. Does the chemical reaction represented by



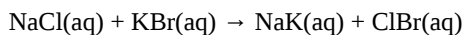
proceed as written? Why or why not?

6. Does the chemical reaction represented by

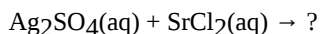


proceed as written? Gold is a relatively useful metal for certain applications, such as jewelry and electronics. Does your answer suggest why this is so?

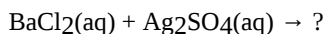
7. Explain what is wrong with this double-replacement reaction.



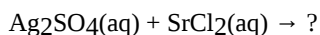
8. Predict the products of and balance this double-replacement reaction.



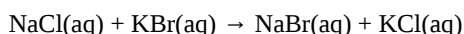
9. Write the complete and net ionic equations for this double-replacement reaction.



10. Write the complete and net ionic equations for this double-replacement reaction.



11. Identify the spectator ions in this reaction. What is the net ionic equation?



12. Complete this reaction and identify the spectator ions. What is the net ionic equation?
- $$3\text{H}_2\text{SO}_4(\text{aq}) + 2\text{Al}(\text{OH})_3(\text{s}) \rightarrow ?$$
13. Can a reaction be a composition reaction and a redox reaction at the same time? Give an example to support your answer.
14. Can a reaction be a combustion reaction and a redox reaction at the same time? Give an example to support your answer.
15. Can a reaction be a decomposition reaction and a redox reaction at the same time? Give an example to support your answer.
16. Can a reaction be a combustion reaction and a double-replacement reaction at the same time? Give an example to support your answer.
17. Why is CH_4 not normally considered an acid?
18. Methyl alcohol has the formula CH_3OH . Why would methyl alcohol not normally be considered a base?
19. What are the oxidation numbers of the nitrogen atoms in these substances?
- N_2
 - NH_3
 - NO
 - N_2O
 - NO_2
 - N_2O_4
 - N_2O_5
 - NaNO_3
20. What are the oxidation numbers of the sulfur atoms in these substances?
- SF_6
 - Na_2SO_4
 - K_2SO_3
 - SO_3
 - SO_2
 - S_8
 - Na_2S
21. Disproportion is a type of redox reaction in which the same substance is both oxidized and reduced. Identify the element that is disproportionating and indicate the initial and final oxidation numbers of that element.
- $$2\text{CuCl}(\text{aq}) \rightarrow \text{CuCl}_2(\text{aq}) + \text{Cu}(\text{s})$$
22. Disproportion is a type of redox reaction in which the same substance is both oxidized and reduced. Identify the element that is disproportionating and indicate the initial and final oxidation numbers of that element.
- $$3\text{Cl}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow 5\text{Cl}^-(\text{aq}) + \text{ClO}_3^-(\text{aq}) + 3\text{H}_2\text{O}(\ell)$$

Answers

- $\text{H}_2\text{O}(\ell) \rightarrow \text{H}_2\text{O}(\text{g})$
- The coefficients are not in their lowest whole-number ratio.
- No; zinc is lower in the activity series than aluminum.
- In the products, the cation is pairing with the cation, and the anion is pairing with the anion.
- Complete ionic equation: $\text{Ba}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) + 2\text{Ag}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{AgCl}(\text{s})$
Net ionic equation: The net ionic equation is the same as the complete ionic equation.
- Each ion is a spectator ion; there is no overall net ionic equation.
- Yes; $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$ (answers will vary)
- Yes; $2\text{HCl} \rightarrow \text{H}_2 + \text{Cl}_2$ (answers will vary)

17. It does not increase the H^+ ion concentration; it is not a compound of H^+ .

19.

- a. 0
- b. -3
- c. +2
- d. +1
- e. +4
- f. +4
- g. +5
- h. +5

21. Copper is disproportionating. Initially, its oxidation number is +1; in the products, its oxidation numbers are +2 and 0, respectively.

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